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INVERTEBRATE CONTROL AGENTS - EFFICACY TEST METHODS

VOLUME VI

LAWNS, ORNAMENTALS, FOREST LANDS

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root mealybugs
greenhouse whitefly
outdoor woody ornamental adelgids
borers
bud and tip destroyers
defoliators
eriophyids
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leaf miners
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ANALYSIS OF SPECIALIZED PESTICIDE PROBLEMS
INVERTEBRATE CONTROL AGENTS - EFFICACY TEST METHODS
VOLUME VI
LAWNS, ORNAMENTALS, FOREST LANDS

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II

Report To The
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By The

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LAWNS, ORNAMENTALS, FOREST LANDS

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INTRODUCTION

Test methods, protocols and procedures for evaluating the effectiveness of invertebrate control agents on turf, ornamentals, forest lands and shade trees are discussed in this report. Specific techniques and methods are documented in selected references, exhibits and other appropriate sources of information. All available references using similar procedures and methods are not cited in order to avoid duplication and repetition. Those cited contain generally accepted protocols and methods, but it is realized that they are not all inclusive and other references may include different methods or variations of those presented. Due to the large numbers of host plants and pests and the limited number of researchers working in subject areas, considerable flexibility in requirements for test methods is necessary.

The scope of organizing test methods for turf, greenhouse and outdoor ornamentals, shade trees and forest lands is briefly addressed in the following comments.

LAWNS AND TURF

Turf throughout the country provides a fairly uniform habitat for invertebrates and creates a situation where methods used for evaluating pesticides on turf pests such as grubs, and sod webworms and chinchbugs are basically similar in many respects. Such factors as insect population densities, soil types and conditions, and turf quality have resulted in variations of basically similar methods or completely novel approaches. Broadly accepted and commonly used methods to evaluate pesticide effectiveness on other turf pests or localized pest problems such as mole crickets, hyperodes weevil, flea beetles, vegetable weevils, fruit flies, millipedes, centipedes, sowbugs, slugs and snails are not readily available. This is due to the limited number of researchers concentrating their efforts on these problems.

GREENHOUSE FLORICULTURAL CROPS

It is nearly impossible to produce a commercially acceptable greenhouse floricultural crop without conducting an effective pest control program. Although, compared to field crops, there are relatively few insect and mite pests that attack greenhouse crops, the pests that are present can cause severe injury. There is also a great diversity of greenhouse crops that are attacked, and, generally, there are many cultivars (varieties) produced on a year-round basis. These factors coupled with

the relatively few environmental hazards (natural enemies, cold, storms, etc.) faced by the pest populations, create a unique situation and make it difficult to standardize test procedures for even the major pests on each major crop.

OUTDOOR WOODY ORNAMENTALS

Woody ornamentals are generally produced in commercial nurseries and are used for landscaping public and institutional buildings, parks, industrial sites, home grounds, etc. Such plants include a nearly infinite and constantly increasing number of cultivars, contained in more than 1000 species, 150 genera, and 60 families. Approximately 2000 species of invertebrates attack these plants (Westcott 1973). Because of the large number of hosts and pests, and the limited number of active researchers, evaluation of insecticides on outdoor woody ornamentals and shrubs is difficult and, therefore, specific test methods for every pest are not available.

FOREST AND SHADE TREES

Approximately one-third of the total land area of the continental United States and coastal Alaska is covered by forests, and about 500 species of insects cause damage to these forest trees. Pesticides are developed to prevent attack or to destroy existing pest populations in these forests. The efficacy of these compounds is evaluated by the Insect and Disease Suppression programs of the U.S. Forest Service and other investigators. The programs evaluate pesticides used on insects that attack shade trees as well as forest trees, and pesticides that are applied to a single tree or thousands of trees in single or multiple applications. The test procedure used is determined by the pest problem under consideration.

Reference

Westcott, C. 1973. *The Gardeners Bug Book*. Doubleday, Garden City, N.Y. 689 pp.

GENERAL CONSIDERATIONS

The test methods in this report are suggested for evaluating the effectiveness of pesticides for control of invertebrates on lawns and turf, greenhouse floricultural crops, woody ornamentals, and forest and shade trees. These methods are to be used as guides and will require revision and updating periodically, as well as the addition of others. The procedures and methods are organized on a pest grouping basis due to the numbers of both invertebrates and host plants involved.

Certain aspects concerning test site location, experimental design, reporting of data including phytotoxicity, and analysis of data applicable to most test methods are:

Location of Test Site:--Outdoor application sites should be selected where known infestations exist and should reflect variations in environmental conditions which may be encountered.

Greenhouse applications, due to their controlled environments, are similar, regardless of location. Normally, data from three locations is adequate as long as they cover the range of variation in temperatures, relative humidity, growing practices, etc., likely to be encountered.

Experimental Test Design:--A sound experimental test design should be used to reduce variability but yet be practical. Random observation or pretreatment counts may be used to determine population distribution and/or to provide guidance in establishing plot location. Experimental designs generally used are randomized complete block design, completely randomized design or Latin square.

Generally, four to six replicates are desirable, but three may provide adequate data. There are cases where neither of these criteria may be met, due to limited plant availability, size or area infested and uniformity of the infestation. Larger numbers of replications may be used when an infestation is sparse and uneven. In cases such as greenhouse testing, where an entire greenhouse may be fumigated, a series of individual trials over a period of time utilizing a single greenhouse may provide adequate data.

Reporting of Data:--A thorough and complete reporting of test data is essential to draw conclusions concerning the effectiveness of a pesticide. Refer to the Guidelines for Registering Pesticides, for desired variables that should be reported. All parameters addressed in the General Considerations and those specific considerations incorporated in each test method should also be reported.

Phytotoxicity:--Due to the complexity of subject areas of interest and the sizable number of plant hosts involved, it is apparent and necessary that plant tolerance to pesticide applications be considered. This is an integral part of evaluating the effectiveness of pesticides since plants differ in their response to chemicals.

Phytotoxicity data is pertinent since a product registered for use against a pest on one host may be registered for use against that pest on another host, providing phytotoxicity data indicates plant tolerance.

Analysis of Data:--Statistical analysis of data should be applied wherever possible using a simple analysis such as Duncan's Multiple Range Test, or an analysis of variance. If significant differences are obvious without analysis of variance, a comparison of means would suffice. Evaluation of results usually involves counting the number of pests which survive the treatment and comparison of this with an untreated check and/or standard commercial treatment (check). Presentation of means and percent control compared to an untreated check or commercial standard (check) is common practice.

Additional Considerations:--Application techniques, sampling techniques, sampling intervals, and pertinent details differing from those provided under General Considerations are described either under the applicable subject area or each individual test method which follows.

LAWNS AND TURF

The test methods for evaluating the effectiveness of pesticides on invertebrate pests of lawns and turf are organized on a pest group basis, including insects such as chinch bugs, grubs and sod webworms. The comments offered under General Considerations are applicable to these test methods unless otherwise specified.

Chinchbugs

The following procedures have proven successful for evaluation of effectiveness of insecticides for control of chinchbugs: *Blissus leucopterus hirtus* Montandon and *Blissus insularis* Barber.

Experimental Design:--The experimental design commonly used to test the effectiveness of insecticides, which yields data suitable for simple statistical analysis utilizes a 3m x 3m (equivalent to 10' x 10') plot (Kerr 1962, Polivka 1963, Reinert 1972, Streu and Cruz 1972) with treatments arranged in a randomized complete block design (Kerr 1962, Reinert 1972, Streu and Cruz 1972). Pretreatment counts are usually taken for the purpose of establishing population uniformity and to provide guidance in establishing the experimental design (Kerr 1962, Reinert 1972, Streu and Cruz 1972). Alleyways between plots are desirable to prevent pesticide contamination when applying treatments, but are not always practical.

Application Methods:--Granular formulations are usually applied by using a shaker can (Reinert 1972) or a lawn fertilizer spreader (Polivka 1963). Wettable powder and emulsifiable concentrate formulations are mixed with water and usually applied with a sprinkling can (Reinert 1972, Polivka 1963), but may be applied with a pressurized sprayer or other suitable calibrated applicator. Watering plot areas prior to treatments to moisten the turf and/or thatch is a desirable practice (Kerr 1962). It is not always applicable due to turf conditions, thatch thickness, etc. and may also depend upon whether liquids or granules are being applied. Watering plot areas following application (Kerr 1962, Reinert 1972, Streu and Cruz 1972) is a common practice where applicable, for the purpose of washing the insecticide into the zone of insect activity.

Sampling and Counting Techniques:--Chinchbug counts are taken by forcing a metal cylinder (open at both ends), covering an area of approximately 0.06 sq. m to 0.09 sq. m (equivalent to two thirds to one square foot), into the turf (Kerr 1962, Reinert 1972, Streu and Cruz 1972). The cylinder is filled with water and the live chinchbugs which float to the surface in a 7 to 10 minute period are counted (Kerr 1962, Reinert 1972, Streu and Cruz 1972). One (Kerr 1962, Reinert 1972) to three (Streu and Cruz 1972), Polivka 1963) samples may be taken per replication. Actual counts should be recorded. In high density populations, such as those that occur in Florida, counts in excess of 100 chinchbugs are recorded as 100, and counting stopped at that factor (Reinert 1972).

Sampling Intervals:--Counts of live chinchbugs should be taken within a 7 day period (Reinert 1972) following application, to provide a measure of initial kill. Subsequent counts may be taken on a one (Reinert 1972), two (Kerr 1962, Streu and Cruz 1972) or four to six (Polivka 1963, Streu and Cruz 1972) week intervals, extended over a period of time sufficient to determine the residual effectiveness of the treatments.

References

Kerr, S. H. 1962. Lawn insect studies - 1962: Chinchbugs. *Proc. Annu. Fla. Turf-Grass Manage. Conf.* 10:201-208.

Polivka, J. B. 1963. Control of hairy chinchbug, *Blissus leucopterous.* Mont., in Ohio. *Ohio Agric. Res. Dev. Cent. Res. Circ.* 122:1-8.

Reinert, J. A. 1972. Control of the Southern chinchbug, *Blissus insularis,* in South Florida. *Fla. Entomol.* 55(4):231-235.

Streu, H. T. and Carlos Cruz. 1972. Control of the hairy chinchbug in turf-grass in the Northeast with Dursban insecticide. *Down to Earth* 28(1):1-4.

Grubs

The following procedures have proven successful for evaluation of effectiveness of insecticides for controlling larval stages of the Japanese beetle, Northern and Southern masked chafers, European chafer, Oriental beetle, Asiatic garden beetle and *Phyllophaga* sp.

Experimental Design:--A commonly used experimental design to test the effectiveness of insecticides for control of grubs utilizes plot sizes ranging from 3 m x 3 m (10' x 10') to 7.5 m x 7.5 m (25' x 25') (Dunbar and Beard 1975, Gambrell et al. 1968, Tashiro and Fiori 1969). This allows for sampling and resampling at periodical intervals. Treatments are usually arranged in a randomized complete block design (Dunbar and Beard 1975, Tashiro and Neuhauser 1973) will yield more dependable results.

Application Methods:--Granular formulations may be applied with a shaker can (Polivka 1965) or a lawn fertilizer spreader (Dunbar and Beard 1975, Tashiro and Neuhauser 1973). Liquids from wettable powders and emulsifiable concentrates should be mixed with water and applied with a sprinkler can (Dunbar and Beard 1975, Polivka 1965, Tashiro and Neuhauser 1973) pressurized sprayer or other suitable calibrated applicator. The method used should provide thorough coverage of the plot area at the desired rate of application. This may be accomplished by applying premeasured amounts to each plot, in two directions at right angles to each other (Tashiro and Neuhauser 1973).

Watering plot areas prior to treatments to moisten the thatch and/or soil is a desirable practice. It is not always applicable due to the turf conditions, thatch thickness, etc. and may also depend upon whether liquids or granules are being applied. Where applicable, plots should be watered thoroughly following application of treatments (Dunbar and Beard 1973, Tashiro and Fiori 1969).

Sampling Techniques:--Since grubs generally feed on the roots of turf, a device for digging and sampling is required. Several suitable tools are available, such as a 175 m x 175 m (7" x 7") ice scraper, a 100 mm (4") diameter metal cut and mechanical sod cutters.

The depth of the sample can be determined by the depth of the grubs. Randomly selected samples of 3 to 10 per plot (Dunbar and Beard 1975, Polivka 1965, Tashiro and Fiori 1969) provides suitable data for analysis. Generally, sampling at least a total area of 0.09 sq. m (1 sq. ft.) per plot is desired, utilizing sample sizes such as 100 mm (4") diameter (Polivka 1965), 160 mm (6.4") diameter (Dunbar and Beard 1975) and 175 mm x 175 mm (7" x 7") sample.

Actual counts of living grubs in each sample should be recorded.

Sampling Intervals:--Parameters of individual tests will determine the intervals for sampling. Spring or summer treatments during the period of grub activity may be evaluated in 1 to 3 weeks following application to determine initial kill or on a 4, 6 to 8 week interval (Dunbar and Beard 1975, Tashiro and Neuhauser 1973) to determine effectiveness and/or residual activity of the insecticide. Generally, summer applications (July-August) directed at killing young grubs are evaluated in the fall (September-October) when the remaining grubs are large enough to be readily found and soil moisture is adequate to allow for proper sampling and examination (Tashiro et al. 1971). Counts on longer term studies following a spring, summer or fall treatment may be taken from a 9 to 12 month period or long intervals (annually) to determine residual control activity (Gambrell et al. 1968).

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Tashiro, H., K. E. Personius, D. Zinter, and M. Zinter. 1971. Resistance of the European chafer to cyclodiene insecticides. *J. Econ. Entomol.* 64(1):242-245

Tashiro, H., and W. Neuhauser. 1973. Chlordane - resistant Japanese beetles in New York. *N.Y. Agric. Exp. Stn. Ithaca Mem. Search. Agric.* 3(3):1-6.

GREENHOUSE FLORICULTURAL CROPS

Methods outlined are designed so that insecticides and acaricides can be evaluated against insects and mites on the following general crop groups (crops listed are examples of major crops with each group):

1. Pot plants (Flowers) - include poinsettia, chrysanthemum, cyclamen, hydrangea, geranium, gloxinia.

2. Cut flowers - includes rose, carnation, chrysanthemum, snapdragon.

3. Bedding plants - includes salvia, petunia, marigold, pansy.

After data are obtained that show a material to be effective in controlling a pest on one crop within a group, that material may be considered effective against that pest on all crops, where it occurs, in the group. However, adequate phytotoxicity data must be obtained on all crops on which a material is to be used.

These methods have been gathered from several sources, and documented by published and unpublished reports. Cited material is only to serve as a guide for a procedure and often many more references containing the same or similar procedure could have been listed.

Application Techniques and Equipment:--Many researchers use small compressed air sprayers (capacity 3.8 - 7.5 liters = 1-2 gallons) in evaluating materials. Others simulate high volume sprays by dipping leaves or plants into insecticide solutions or suspensions (Henneberry and Smith 1965, Webb et al. 1974), or by using small hand-held aerosol propellent cans to spray plants (Lindquist 1974). The common element in all applications is coverage to the point of runoff and no matter which method is used, data obtained from these tests may be used to support results of larger, commercial trials, if proper sampling and adequate replication have been used. However, at least one trial must be conducted with the kind of equipment and under conditions similar to that found in commercial greenhouses to substantiate results obtained from the above trials.

For most pests of greenhouse crops, it is particularly important to direct sprays at the undersides of leaves to contact surfaces where pests are generally found.

Granular insecticides usually are scattered evenly over the soil surface of plant beds or pots or over foliage of closely-spaced plants. Application rates for granular materials are calculated either on the basis of surface area or on volume of soil (Smith 1952). Both procedures may provide adequate efficacy data, depending upon the objectives of the experiment. Following application, water is applied to wash off any granules adhering to foliage and to carry the toxicant down to the root zone. Applications may be made with a shaker jar or broadcast spreader that does not grind the granules.

Liquid systemic insecticides are usually applied in dilute form to the soil of pots or plant beds. Enough solution is applied to carry the toxicant to the root zone (Neiswander 1962).

Aerosols, fumigants, fogs (thermal and non-thermal) are applied at a certain rate per cubic meter, with the appropriate specialized application equipment.

Location of Tests:--Because tests are conducted in greenhouses under controlled conditions, geographical differences are not as critical as when evaluating insecticides under field conditions. Valid data should be obtained from at least three or four different locations.

Plot size:--Plot size for greenhouse evaluations can vary depending on available plant material, number of insecticides included in the test, and whether evaluations are conducted in a research greenhouse or commercial range.

For preliminary, or supplemental testing with insecticides, data obtained in replicated tests with only 1-3 plants per replicate should be considered valid if other test parameters are adequate (Webb et al. 1974, Lindquist 1975). These data can be used as supportive, but should not be considered "primary". At least one trial must also be conducted under commercial growing conditions to validate data obtained in small plot tests.

Replication:--Four replicates are preferred, but at least 3 replicates of each treatment are necessary for statistical analysis of data. In aerosol or other fumigant applications, where an entire greenhouse must be treated, a series of 3-4 trials over a period of time provides a means of replication when insufficient area is available for replication at one time.

Sampling:--Pre-treatment counts are often made to establish the presense of an infestation before selecting plants to be treated or as an aid in designing the experiment. These counts are not always necessary nor are they always included in tabular results.

In some tests, e.g., with aerosols, fumigants, fogs, etc., pre-treatment counts are necessary to establish the efficacy of a treatment. For these treatments a known number of insects or mites may also be put in cages and placed in different areas of the greenhouses to measure efficacy.

It is essential to have temperature records, especially at times when treatments were applied. These data might provide information on the effectiveness of a material over a range of temperatures or a clue as to why phytotoxic symptoms appeared.

Phytotoxicity:--On ornamental plants, phytotoxicity evaluations are equal in importance to efficacy data. Because of the diversity of

species, and cultivars within species, few materials are completely safe on all ornamentals. Therefore, some phytotoxicity is to be expected and the task is to put it in perspective. Measurement of injury can be done by a numerical rating system, or by statements describing the injury symptoms. In all cases, a statement concerning the commercial acceptability of any injury that does appear should be made.

References

Henneberry, T. J., and W. R. Smith. 1965. Malathion synergism against organophosphate-resistant two-spotted spider mites. *J. Econ. Entomol.* 58(2):312-4.

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Twospotted Spider Mite, *Tetranychus urticae* Koch

For methods and statements concerning insect and mite control on all greenhouse floricultural crops, see both the general introduction and introduction to the greenhouse crops section.

Spider mites are probably the most serious pests of greenhouse crops throughout the world (Hussey et al. 1969) largely because of their ability to develop resistance to many acaricidal materials.

Spider mites will feed on and damage some 200 host plants (Hussey et al. 1969) but the few techniques from major hosts listed here may serve as examples of methods for nearly all hosts.

Sampling Procedures:--Some details of sampling procedures may vary with individual host plants, but most fall into several basic categories:

1. Recording mites from a certain number of leaves or flowers. Depending on the host, samples are taken at random, from leaves of similar age, or near leaves that have feeding damage (Baranowski 1966, Binns 1969, Poe and McFadden 1972, Poe and Wilfret 1972).

2. Recording mites from a certain number of leaf discs, removed at random from leaves showing any feeding injury (Taylor et al. 1969).

3. Using bean seedlings as host plants, trimmed of all but 2 leaves. Plants are infested by pinning infested leaves from mite colony to seedling leaves for 2-4 hr., then dipping entire plant in insecticide solutions. Living and dead mites are then recorded from the entire plant (Henneberry and Smith 1965).

4. Using a Henderson-McBurnie mite brushing machine to brush mites onto glass plates coated with a material causing mites to adhere to the surface (Schuder 1974).

In all of the above procedures, some magnification is necessary to make mite counts. Generally, a binocular microscope (12-15X) is used for this purpose.

Reporting Results:--When mites are sampled using one of the general procedures listed above, results can be recorded as:

1. Mean no. mites and/or eggs per leaf, leaflet, leaf disc, or groups of these.

2. Mean no. mites per glass plate, removed from a certain amount of foliage.

3. Average infestation rating.

4. Live and dead mites per plant.

Sampling Interval:--The sampling interval can vary, depending upon the objectives of the experiment, but some common intervals include 24 hr, 7 days, and 14 days post-treatment (see references under sampling procedures).

References

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Aphids

For methods and other information applicable to testing insecticides against all insects on greenhouse floricultural crops, see both the general introduction and introduction to the greenhouse crops section.

Most methods cited concern the green peach aphid, *Myzus persicae*, on greenhouse chrysanthemums. This aphid also infests many other hosts, but little information is available for test methods on these hosts. Other common aphids include the rose aphid, *Macrosiphum rosae*, potato aphid, *Macrosiphum euphorfiae*, and chrysanthemum aphid, *Macrosiphoniella sanborni*. Several other species can and do occur (Hussey et al. 1969).

Because the green peach aphid is the most common species and the most difficult to control (Hussey et al. 1969) efficacy data obtained on a material for controlling this species may also indicates the effectiveness for that material in controlling other species.

Sampling of Treated Population

Aphids on Leaves, Stems, and Terminal Shoots:--Sampling methods can be divided into several basic types, including:

1. Counting aphids on entire plants (Gould 1969, Webb and Smith 1973), or on leaves (Helgesen 1971, Poe and Marousky 1971, Poe and Green 1974). Counting aphids on entire plants should eliminate any variation in location of aphid populations on different cultivars of a host (Markkula et al. 1969, Webb and Smith 1973). However, if samples are taken from the same location on all plants, this potential source of bias may be eliminated.

2. Counting aphids on stems, or recording stems and/or terminal shoots as infested or not infested.

Sometimes recording stems or shoots as infested or not infested is combined with a weighted rating system to give an estimate of the severity of infestation (Overman and Poe 1971, Lindquist 1972). Because aphids in greenhouses are all females that give birth to living young without mating, the presence of one or more aphids on a stem leaf, or flower indicates that there is the potential for a severe infestation (Hussey et al. 1969).

3. Introducing a known number of aphids onto previously uninfested plants just prior to treatment (Helgesen and Tauber 1974).

Aphids in Flowers:--Often, controlling aphids in open flowers is necessary before plants are sold, or insecticides are applied to prevent flowers from becoming infested. Recording the number of flowers with and without aphids (Appleby 1972), the number of live aphids in a number of flowers (Lindquist 1974), or using an extraction technique to separate aphids from flowers (Gray and Schuh 1941) should provide adequate efficacy data.

Aphids are capable of migrating into greenhouses from outdoor plantings, or moving around within greenhouses (Dixon 1971), it often is necessary to obtain an estimate of a material's residual killing power. This can be achieved by placing infested plants among treatments, using untreated check plants as the potential source of a new population, or to reinfest plants at intervals after treatments have been applied (Gould 1969). This latter procedure should provide the most reliable data on residual effectiveness, because aphids are not always in a migratory (winged) stage.

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Flower Thrips, *Frankliniella tritici* (Fitch), (in open flowers)

For general methods and statements concerning insect and mite control on flowering plants, see both the general introduction and introduction to the greenhouse crops section. Most general information contained in the latter section also pertains to floral crops grown out-of-doors.

Sampling Methods:--Sampling treated flowers can be divided into 3 basic methods:

1. The Wash Method (Taylor and Smith 1955, Ota 1968). This procedure involves tearing flowers apart in a detergent solution, allowing flower parts to float to the top and thrips to settle out, then pouring the mixture through a series of different sized screens to separate the thrips from the fluid.

2. The Mechanical Method (Henneberry et al. 1964). Infested rose flowers are torn apart, placed in a plastic container with a screen bottom, and shaken over a wet, black cloth.

3. The Irritation Method (Evans 1933). An irritant, such as turpentine, ethyl acetate, or methyl isobutyl ketone is used to drive thrips out of infested flowers and into a pan of water or onto a paper coated with a sticky substance. Another technique is to use a Berlese Funnel to drive thrips into an alcohol solution (Schuder 1974, Morishita 1975).

According to Ota (1968), the wash method yielded a significantly higher percentage of thrips than the other 2 methods. However, if efficacy of an insecticide is being measured, it should only be necessary to obtain relative abundance figures, not absolute numbers.

Reporting of Results:--With all of the techniques above, results were reported as number of thrips per flower, or groups of flowers.

Sampling Interval:--After applications of an insecticide, the first samples usually are taken 1 day after treatment (Henneberry et al. 1961, Lindquist 1972, Schuder 1974). Following this initial sample, subsequent counts to measure residual action can be made at the discretion of the researcher.

References

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Iris Borer, *Macronoctua onusta* Grote (on iris)

For general methods and statements concerning insect and mite control on outdoor flowers, see both the general introduction and introduction to the greenhouse crops section. Most general information contained in the latter section also pertains to floral crops grown out-of-doors.

Sampling Methods:--Only two basic methods for sampling treated areas were found in the literature, and they depnd on the season of the year. Iris borers begin their development on and within leaves during April, May or June, and eventually bore down into the rhizomes in July and August. Pupation usually occurs in the soil near infested rhizomes (Neiswander 1961). Thus, one method involves examining a certain number of leaves for larvae, or larval feeding injury (Schuder 1958). The second technique is to examine rhizomes and/or surrounding soil for injury, larvae, or pupae. This usually means digging up the treatments, or portions thereof, and physically inspecting rhizomes or searching the soil (Schread 1970, Dunbar 1975). The first method is valid during the early part of the season, and the second during the latter part.

Reporting of Results:--If leaves are examined for larvae, results may be recorded as percent dead, no. live or no. dead (Schuder 1958). Results of examination of rhizomes and soil usually are reported as mean no. live larvae or pupae per plot (Schread 1970, Dunbar 1975).

Sampling Interval:--The interval between treatment and recording of results will depend upon whether the researcher measures early-season larval control in leaves, or wishes to wait until larvae have entered rhizomes and/or pupated. If leaves are to be examined, counts should be made by mid-June in most areas. Rhizomes and soil can be examined during August (Neiswander 1961, Schread 1970).

References

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Root Mealybugs, *Rhizoecus* spp. (on container-grown greenhouse floricultural crops)

For methods and statements concerning all insects on greenhouse floricultural crops, see both the general introduction and introduction to the greenhouse crops section.

Application Methods:--Depending on the formulation used, 3 application methods are employed:

1. Spreading granules on soil surface (Poe 1972, Poe et. al. 1973, Hamlen 1974).

2. Applying liquid suspensions as soil drenches (Poe 1972, Poe et. al. 1973, Hamlen 1974).

3. Submerging pot and root ball for a certain amount of time (5 minutes) in insecticide suspensions (Poe 1972).

Sampling Methods:--Mealybug populations are measured by lifting each plant from its container and counting individuals lying adjacent to the exposed roots on the outside of the root ball (Poe 1972). These counts may be made in a restricted band (Hamlen 1974).

Reporting Tabular Data:--Efficacy can be reported as percent control, compared with untreated checks (Poe 1972), or mean no. individuals per plant (Hamlen 1974).

Sampling Interval:--Counts of mealybugs are made, beginning 7 days post-treatment (Poe 1972), and at weekly or bi-weekly intervals thereafter (Hamlen 1974).

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Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood)

For methods and other information applicable to testing insecticides against all insects on greenhouse floricultural crops, see both the general introduction and introduction to the greenhouse crops section.

Most of the emphasis is on evaluation of materials to control the immature stages (egg, nymphs, "pupae" - the last nymphal instar), rather than the adult stage. There are two reasons for this: (1) the adult is susceptible to many materials, and although it is desirable to control this stage, a material is more valuable if it controls the developing nymphs because fewer applications will be necessary; (2) adults are able to fly among the treatments, and mortality is difficult to assess unless treatments are separated by some physical barrier (screens, separate greenhouse compartments, etc.). Therefore, beyond rather immediate killing power of a material, residual effects on adults are hard to measure.

Pest Population

Greenhouse whitefly populations usually are readily available in most greenhouses, and few specific rearing instructions for the insects should be necessary. However, large numbers of whiteflies can be reared on tobacco plants, or on the specific host plants to be used in the tests.

Rearing can be done in a separate greenhouse compartment or caged area within a compartment, and the adult population used to obtain life stages of known age (Smith et al. 1970, Webb et al. 1974).

Because whiteflies normally develop from the apical portion of the plant downward on undersides of leaves, similar age group distribution can be obtained by selecting these areas to make counts (adults and eggs on apical leaves, nymphs and pupae on subapical leaves).

Sampling of Treated Population

Adults:--Sampling adult populations normally involves counting them on a certain number of apical leaflets (Lindquist 1972), on the entire plant (Webb et al. 1974), or on blackened glass plates (or paper) placed among the plants (Smith et al, 1970, Webb et al. 1974). All of these procedures may give reliable data on whitefly adult mortality. Residual killing can only be measured by using glass plates or paper, or by caging adults on treated leaves at intervals after application (Krueger et al. 1973). If glass plates or paper are used, dead adults must be removed each time data are recorded. The other methods give only estimates of immediate kill, unless treatments are physically separated by a barrier (cages) or in separate greenhouses.

In some cases, e.g., aerosol or fumigation trials when materials must be applied to an entire greenhouse or greenhouse compartment, pre-treatment and post-treatment counts will be necessary (Lindquist 1974).

Nymphs and Eggs:--There are many procedures used to evaluate control, or mortality, of whitefly immature stages. Procedures mentioned can be used to develop reliable data, with adequate replication.

1. Recording life stages from entire leaves, leaflets, or per unit of leaf area. This can be done if the same plant species (or cultivar) is utilized for efficacy trials. This method was used by Smith et al. (1970), Webb et al. (1974), Krueger et al. (1973), Lindquist (1974), and Schuder (1974).

2. Recording life stages from portions (e.g., 1/2) of leaves. The same criteria apply as in (1) above.

3. Recording life stages from uniform-sized leaf discs or punches. This method should give the best estimate of populations if several cultivars of the same species or several different species are included in a trial, because the area sampled will be equal for all plants. Discs or punches should be removed from the same relative areas on all plants to insure an uniform age distribution of sampled population. See Smith et al. (1970), Allen (1972), Lindquist et al. (1972) for examples of this procedure.

4. Recording the number of live and dead life stages in the first 50 or 100 encountered (Webb et al. 1974).

Recording of Efficacy Data

Adults:--Can be recorded as no. alive per sampling unit (leaf, leaflet, plant), or no. dead per glass plate or paper square.

Immature States:--These data can be recorded in several ways (Smith et al. 1970). Schuder (1974) counted live nymphs plus empty "puparia" (i.e., adults had emerged). This procedure should provide adequate data if pre-treatment observations establish that only young nymphs are present.

Intervals after treatment for recording data may vary. Adult mortality can be measured within a few hours, but if effects on immature stages are to be measured, it will be necessary to wait at least 7 days before any effects are noted. Appropriate intervals are found in Smith et al. (1970), Allen (1972), Schuder, (1974).

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OUTDOOR WOODY ORNANMENTALS

The most common outdoor woody ornamentals and shrubs include arborvitae, azalea, boxwood, camellia, chamaecyparis, cotoneaster, crabapple, dogwood, euonymus, forsythia, holly, honeylocust, juniper, laurel, lilac, magnolia, oleander, palm, pine, privet, pyracantha, redbud, rhododendron, spirea, viburnum and yew. For the purpose of pesticide test methods development, pests of woody ornamentals may be conveniently grouped as aphids, adelgids, borers, bud and tip destroyers, bugs, defoliators, eriophyids, gall insects, leafminers, mealybugs, root feeders, scales, tetramychids, and thrips. Test methods applicable to each of these groups are given under their respective headings. The following general statements are applicable to all of these groups:

Application techniques should be appropriate for the use contemplated and the size of the test plots used. Frequently, hand-pumped, compressed air sprayers are used in evaluating materials for efficacy on woody ornamentals. Results from such applications are comparable to those obtained with power equipment provided that the same dilution is used and the same amount of toxicant per plant unit is applied. Commonly this is achieved by spraying to run-off (Campbell 1968). Systemic materials applied to the soil should be evenly distributed over the active root zone and this is assumed to be an area around the stem equivalent to the area covered by the foliage. Dosages are calculated on a surface area basis or on the basis of stem diameter of the host (Tashiro 1973). The systemic materials are applied to moist soil, may be incorporated, and watered in (Scheer & Johnson 1970, Saunders 1970). Dosages for container grown plants are calculated as shown by Smith (1952). Other application techniques such as ULV, LV, trunk drenches, implantation, soil injection, or aircraft treatments may be used when appropriate.

Experiments should be designed to yield valid data. It is desirable to use field plots of a size sufficiently large to be representative of actual use practices consistent with good field plot technique. Supportive data any include results from tests wherein each plot is a single plant or, in unusal circumstances, a single branch (Koehler 1964). Generally four replicates are appropriate, although three may be used if test plants are limited and the infestation is uniform. More than four may be required when the infestation is sparse or uneven (Koehler 1963, Nielsen et al. 1973). To enhance validity of tests it is common practice to select test plants that are known to be infested, before randomization of the plots. This may be done by taking pre-treatment counts (Reinert 1973). Pre-treatment counts may also be used to provide guidance in establishing the experimental design (Reinert and Woodiel 1974).

Evaluation of results usually involves counting the number of pests which survive the treatment and comparison of this with an untreated check and/or a standard commercial check. An indication of population reduction by reporting percent control in relation to an

untreated check is common practice (Campbell 1968). Rating schemes may be appropriate, but they must be fully explained (Campbell and Balderston 1969). Efficacy may be evaluated on the basis of plant protection, rather than on counts of living insects, when appropriate. For example, it is immaterial whether a leaf miner is dead or alive if it has already destroyed the aesthetic value of the leaf in which it occurs and so it is reasonable to assess the efficacy of a pesticide on the basis of the number of leaves marred per test plant in comparison to an untreated check (Hartzell et al. 1943). The concept of an Aesthetic Injury Level in contrast to the conventional Economic Injury Level is valid.

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Adelgids

On spruce, where the object of control is prevention galls, observations on efficacy should be made after new growth has developed. At other times of the year counts of living adelgids per unit length of twig are useful supplemental data (Campbell and Balderston 1972b). On hosts where the object of control is population reduction of free-living adelgids, counts of living adelgids per plant unit (length of twig, area of bark, etc.) are appropriate. These plant units should be chosen at random from each plot and the counts should be averages of at least three subsamples per plot (Campbell and Balderston 1972a).

References

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Aphids

Colonies to be treated experimentally should be composed predominately of apterous nymphs. The presence of substantial members of parasites of predators at the time treatment may confound results of the trial. Some species of aphids are easily dislodged by a spray stream regardless of toxicant, especially if a high pressure spray is used. In this case it is advisable to include a "water only" spray treatment as the untreated check to ensure validity of the results.

Observations on effectiveness can be made 24 hours after treatment and should be repeated at 48 hours and then continued on a weekly basis until population levels on treated plants again approximate those on untreated checks. Counts of living aphids are usually based on some convenient plant unit (length of stem, number of leaves, etc.). These sampling units should be chosen at random from each plot and the counts should be averages of at least three subsamples per plot (Reinert and Woodiel 1974). Beating trays or other mechanical devices may be used for sampling plots if the above principles regarding randomization and subsampling are adhered to (Campbell 1968).

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Borers

Usually entire susceptible portions of plants are treated but Neiswander (1961) used excised bolts successfully. Evaluation of results may be made by counting the number of adults which emerge from treated wood (Appleby 1973), counting new attacks on susceptible plant parts (Coster et al. 1972), or by indexing schemes such as the frass indexing scheme used by Nielsen et al. (1973).

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Bud and Tip Destroyers (including shoot moths, tip moths, tip midges and budworms)

Results of trials may be evaluated by examining entire plants for surviving insects (Pree and Saunders 1972), by examining appropriate plant units (Campbell 1968), by counting the number of adults which emerge from the test plants (Appleby and Neiswander 1966), or by an appropriate rating scheme (Koehler and Tauber 1964). Combinations of these are also used. Cocoons per unit weight of foliage were counted 10 months after treatment and an insect damage rating scheme was used by Koehler (1974). If plant units are used they should be selected at random from each plot and the counts should be averages of at least three subsamples per plot.

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Bugs (including true bugs, leafhoppers, spittlebugs, whiteflies, psyllids)

Efficacy of materials tested against relatively inactive species may be assessed by counting all living bugs on each plant (Johnson 1960) or by counting them on randomly selected subsample from each plant (Koehler 1973, Koehler and Rosenthal 1967). For active species which may move off plants or be easily dislodged one can use an injury rating system (Koehler 1962).

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Defoliators (including caterpillars, leaf beetles, sawflies, skeletonizers)

When test plants are small it is possible to count survivors per plant (Koehler 1973). Timed-count procedures were used successfully in oakworm trials by Koehler (1975). Larvae were not removed after counting and so were were available for counting at subsequent sampling intervals. Using a stopwatch, a person would record the number of live larvae seen in a one or two minute search of intact foliage. Another one or two persons would follow the same procedure in the same plot. Alternatively several people can enter the same plot at the same time, with a timer left outside. Nielsen et al. (1971) examined each plant for 30 man-records and recorded the number of leaves with at least one weevil. Efficacy of ovicides can be evaluated by determining percent hatch (Swenson et al. 1969).

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Eriophyids

For species which cause galls or other distinctive plant symptoms, rating of damage may be used as an indication of efficacy (Campbell 1969). Free living forms may be counted by examining appropriate plant material with the aid of a microscope (Saunders and Barstow 1972).

References

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Saunders, J. L., and D. A. Barstow. 1972. *Trisetacus campnodus* control on *Pinus sylvestris*. *J. Econ. Entomol.* 65(2):500-501.

Gall Insects (See also specific test methods for Adelgids)

Counts of cynipid leaf gall wasps can be made prior to leaf drop (Koehler 1964) using enough leaves per plot to assure validity of results. Galls may be collected and examined for living inhabitants, reporting the % galls with live aphids (Koehler 1974).

References

Koehler, C. S. 1964. Control of *Asterolecanium* scales and cynipid leaf galls on oak in Northern California. *J. Econ. Entomol.* 57(4):579-581.

_____. 1974. Evaluation of 3 types of application of insecticides for control of the lettuce root aphid, *Pemphigus bursarius*, on Lombardy Poplar. (Exhibit 15).

Leafminers

The proper interval between treatment and evaluation depends on the species involved (Matthysse and Naegele 1952), but in any case counts must be made before injured leaves drop from the plants (Hartzell et al. 1943). Species (such as some infesting conifers) which cause symptoms other than mines can be evaluated by counting the number of such sites (Tashiro 1974). Typically the proportion of damaged leaves on treated and untreated plants is compared by examining an appropriate number of leaves per plant (Kulp 1963).

References

Hartzell, A., D. L. Collins, and W. E. Blauvelt. 1943. Control of the holly leafminer. *Contrib. Boyce Thompson Inst.* 13(1):29-34.

Kulp, L. 1963. Control of the native holly leaf miner, *Phytomyza ilicicola* (Diptera: Agronyzidae). *J. Econ. Entomol.* 56(6):736-739.

Matthysse, J. G., and J. A. Naegele. 1952. Control of several tree and shrub leaf miners. *J. Econ. Entomol.* 45(3):377-383.

Tashiro, H. 1974. Biology and control of the spruce needle miner. *J. Econ. Entomol.* 67(1):89-92.

Mealybugs

Root inhabiting forms may be counted by lifting each plant and counting individuals on the exposed roots (Poe 1972). Stem or leaf inhabitants may be counted by examining aerial portions of plants (Campbell and Balderston 1971).

References

Campbell, R. L., and C. P. Balderston. 1971. Insecticidal control of grape mealybug on *Taxus* nursery stock on Ohio. *J. Econ. Entomol.* 64(4):985.

Poe, S. L. 1972. Treatment for control of a root mealybug on nursery plants. *J. Econ. Entomol.* 65(1):241-242.

Root Feeders (including weevils, wireworms, grubs)

The type of soil or other medium in which the plants are grown must be specified and, if container grown, the volume of medium should be stated (Saunders 1970). Evaluation should be made by counting living insects in the root area (Saunders 1970).

Reference

Saunders, J. L. 1970. Carbofuran drench for black vine weevil control on container-grown spruce. *J. Econ. Entomol.* 63(5):1698-1699.

Scales

The stage of development of the scales when treated must be specified (Smith et al. 1971). If foliar treatments are being tested against migrating crawlers it may be necessary to account for mechanical dislodgement. This may be done by including a "water only" treatment as the untreated check. Efficacy may be determined by counting survivors per plant unit (Koehler et al. 1965) or by determining percent mortality by examining a given number of individuals per plot (Nielsen and Johnson 1972).

Determination of individual scale mortality differs according to whether the scale species is armored or not. Kouskolekas and Self (1972) evaluted relative effectiveness of treatments for the armored tea scale on the basis of mortality of adult females at monthly or bimonthly intervals after treatment. Leaf samples of 3-4 infested leaves were taken from the middle and upper portion of each plant. Female scales were selected at random, the test was removed, and mortality was determined under magnification. At each sampling date two mortality counts of 100 females were made and averaged.

Koehler et al. (1965) evaluated results of trials against the unarmored irregular pine scale by taking 5 current-season twigs from

each plot and determining mortality of scales on them by puncturing each with a needle under magnification; live scales exude a clear-yellowish fluid when punctured while dead scales are either dry or exude a discolored fluid.

Evaluation may be delayed to allow residues to dissipate and survivors to mature to a size which can be easily counted (Koehler 1974).

References

Koehler, C. S. 1974. Evaluation of insecticides and spraying schedules for control of Kuno scale, *Lecanium kunoensis*, or pyracantha. (Exhibit 16).

Koehler, C.S., M.E. Kattoulas, and R.L. Campbell. 1965. Timing of treatments for control of the irregular pine scale. *J. Econ. Entomol.* 58(6):1102-1105.

Kouskolekas, C. A., and R. L. Self. 1972. Control of tea scale on container-grown camellias with systemic insecticides. *J. Econo. Entomol.* 66(5):1163-1166.

Nielsen, D. G., and N. E. Johnson. 1972. Control of the pine needle scale in central New York. *J. Econ. Entomol.* 65(4):1161-1164.

Smith, F. F., A. K. Oto, C. W. McComb, and J. A. Weidhaas, Jr. 1971. Development and control of a wax scale, *Ceroplastes ceriferus*. *J. Econ. Entomol.* 64(4):889-893.

Tetranychids

Mite control on broad leaved plants may be evaluated by weekly counts under magnification of the number of live mites per leaf using adequate subsampling procedures (Wilson and Oliver 1969). On narrow-leafed evergreens samples of twigs may be taken and counts made of live mites per twig (Matthysse and Naegele 1952). Twig lengths should be standardized or else the counts should be reported on the basis of number per cm. of twig. Alternatively mites can be extracted from foliage samples by exposure to an irritant such as methyl isobutyl ketone (Koehler and Frankie 1968).

References

Koehler, C. S., and G. W. Frankie. 1968. Distribution and seasonal abundance of *Oligonychus subnudus* Monterey pine. *Ann. Entomol. Soc. Am.* 61(6):1500-1506.

Matthysse, J. G., and J. A. Naegele. 1952. Spruce mite and southern red mite control experiments. *J. Econ. Entomol.* 45(3):383-387.

Wilson, N. L., and A. D. Oliver, 1969. Evaluation of some acaricides for control of spider mites on three woody ornamentals in Louisiana. *J. Econ. Entomol.* 62(6):1400-1401.

Thrips

Reinert (1973) evaluated efficacy by counting the average number of thrips per leaf on 8-12 subsamples per replicate at weekly intervals after treatment and this allowed him to determine the residual period of each material in the test.

Reference

Reinert, J. A. 1973. Cuban laurel thrips: systemic insecticides for control. *J. Econ. Entomol.* 66(5):1217-1218.

FOREST AND SHADE TREES

Insecticides are tested for use on forest lands either to prevent damage from, or to destroy, existing insect pest populations. Approximately one-third of the total land area of the continental United States and coastal Alaska is covered by forests. There are about 500 different species of insects that cause damage to forest trees. However, insecticides are generally developed for use only against those pests which have received attention in U. S. Forest Service Insect and Disease Regulatory Programs and by other investigators in various sections of the United States. These programs cover a wide spectrum of forestry uses and may encompass treatments of from single trees to thousands of acres in single or multiple applications. Because of the large acreages involved, and the amount of publicly owned forest lands, public agencies also conduct their own insecticide evaluation tests in the public interest. It is estimated that defoliating insects and bark beetles are responsible for 40% of all tree mortality from all destructive sources, therefore, for the purpose of test method guidelines, these are the only insect pests dealt with. Few insecticides have been developed that can be used to suppress or control large-scale outbreaks of destructive forest insects.

Experimental Design (General):--It is desirable to use the largest plot size practicable with aircraft application as soon as chemical effectiveness is proven, to reflect actual field practices and obtain operational dosage rates. Therefore, minimum plot size is generally 50 acres in a fixed-wing aircraft test, 20 acres for helicopter, and 1-3 individual trees for backpack or hydraulic sprayer studies. Corners of plots using aircraft should be marked for guidance using helium filled kytoons, groups of balloons, or other highly visible markers (Doane 1966, Doane and Dunbar 1973, USDA 1975). Study areas are usually established with the following minimum criteria:

1. An area in which insect pest population is building and which no more than one year's noticeable defoliation or damage has occurred prior to the test year, to insure that natural virus incidence is minimal.

2. A readily measurable population is present.

3. Predominance of preferred host trees suitable for population sampling (USDA 1974).

Three replications of each concentration tested are generally used with a minimum of five replicate sample stations within each plot. Foliage protection is frequently as important as population reduction as an efficacy criterion (USDA 1974).

References

Doane, C. C., 1966. Field tests with newer materials against the gypsy moth. *J. Econ. Entomol.* 59(3):618-20.

Doane, C. C. and D. M. Dunbar, 1973. Evaluation of insecticides against the gypsy moth and elm spanworm and repellant action of chlordimeform. *J. Econ. Entomol.* 66(5):1187-89.

USDA. 1974. Final environmental statement on the cooperative 1974 gypsy moth suppression and regulatory program, USDA Forest Service and Animal and Plant Health Inspection Service. March 29, 1974. Unpubl.

USDA. 1975. Pilot project work plan for 1 and 2 aerial applications of fenitrothion for control of western spruce budworm 1975. US Forest Service, Region 6, Portland, OR. Unpubl.

Gypsy Moth - *Porthetria dispar* L.

Experimental Design:--Generally two parameters are examined in an efficacy evaluation study: foliage protection and population reduction. Study areas with 100-900 egg masses/acre (Herbaugh et al. 1975) and a predominance of oak trees are appropriate. Infested apple orchards lend themselves well for ground application studies (Doane 1966).

Application Methods:--Experimental test plot sizes for ground application are a minimum of 0.05 acres with 5-25 acres sufficient for an aerial test; four studies are conducted on proven insecticides using triplicate plots of 150 acres or larger. More than one geographic area is desireable (USDA 1975). Application is usually made when the majority of larvae are in late 2nd instar with oak foliage 50-75% expanded.

Sampling Methods:--Foliage protection is estimated by visual examination in 20% increments before and after treatment on 1/40th acre subplots on all tree species on both test and control plots. Population reduction is estimated by measuring the percent mortality due to treatment as evidenced by pre- and post-treatment square-yard drop cloth counts (Merriam et al. 1970, USDA 1975) and pre- and post-treatment egg mass counts (Herbaugh et al. 1975). Estimates of residual population are usually measured by 24 inch terminal branch larval counts (AFRI 1972), by 5 or 10 minute timed counts on 1/10th acre (Merriam et al. 1970, Doane 1966) or on 1/40th acre subplots (USDA 1975), or by larval counts under burlap bands (Merriam et al. 1970).

Reduction of populations to less than 250 egg masses/acre generally will not require retreatment. Usually the measurement of treatment effects should be followed into the following season.

References

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Herbaugh, L. L., W. H. McLane and C. R. Stacy. 1975. Field evaluations of insecticides against the gypsy moth, *Porthetria dispar* L. Gypsy Moth Methods Development Laboratory, Otis AFB, MA. Unpubl. 27 pp.

Merriam, W. A., G. C. Tower, E. C. Paszek and J. L. McDonough. 1970. Laboratory and field evaluation of insecticides against the gypsy moth. *J. Econ. Entomol.* 63(1):155-59.

Spruce and Western Spruce Budworm - *Choristoneura fumiferana* (clem.) and *C. occidentalis* Freeman

Experimental Design:--Study areas 20-1000 acres in size with a predominance of spruce/fir or Douglas-fir having more than 8 larvae per 100 square inches of bark surface/mid-crown branch are appropriate (USDA 1975, Schmiege et al. 1970).

Application Methods:--Treatment is generally scheduled shortly after 75% of the larvae reach 5th instar (USDA 1975) or in late 4th instar (USDA 1974). Instar identification is determined using Carolin's larval head capsule characteristics (Carolin and Coulter 1972).

Sampling Methods:--Unually 15 trees/plot in the range of 30-50 feet high are selected as sample trees. From 2-4 fifteen-inch branch samples are excised from the mid-crown region of each tree. Population density is expressed as larvae/100 new buds or shoots (USDA 1975, Honing 1968, McCowan et al. 1973). Foliage protection is usually measured by optical examination of volume of feeding on 100 buds/tree, recorded as percent defoliation to nearest 10% (USDA 1975, USDA 1974).

References

Carolin, V. M. and W. K. Coulter. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. Pac. NW Forest and Range Experiment Station. Res. Paper No. 149. 38 pp.

Honing, F. B. 1968. Spruce budworm Zectran pilot control test-1966. USDA Forest Service, Northern Region. 12 pp. Unpubl.

McCowan, V. F. and D. A. Stark. 1973. Operational test of mexacarbate (Zectran) against spruce budworm in Main-1973. US Forest Service, Northeastern Area State and Private Forestry, Upper Darby, PA. Rept. No. P-73-5.

Schmiege, D. C., C. E. Crisp, R. L. Lyon, P. Miskus, R. B. Roberts and P. J. Shea. 1970. Evaluation Report on Zectran as a substitute of DDT in control of western spruce budworm. US Forest Service, Pac. SW Forest and Range Exp. Sta. Berkley, CA. Unnumbered Rpt. 35 pp.

USDA. 1974. Final environmental statement on cooperative spruce budworm project. Maine 1974 Activities. Northeastern Area, State and Private Forestry, Upper Darby, PA. 102 pp.

USDA. 1975. Pilot project work plan for 1 and 2 applications of fenitrothion for control of western spruce budworm-1975. US Forest Service, Region 6, Portland OR. Unpubl.

Douglas-fir Tussock Moth - *Orygia pseudosugata* McD.

Experimental Design:--Study areas 20-1000 acres in size with a predominance of Douglas-fir or true firs having 20 or more larvae and/or egg masses/1000 square irches of foliage are usually appropriate (USDA 1974, Mason 1970).

Application Methods:--Treatment is generally schedule shortly after 70% of the egg masses have hatched (USDA 1974).

Sampling Methods:--Usually 15 trees/plot in the range of 30-50 feet high are selected as sample trees. From 2-4 eighteen-inch branches are excised from the mid-crown region of each tree. Population density is expressed as larvae/1000 square inches of foliage (USDA 1974). Foliage protection is measured by optical examination of volume of feeding on 100 buds/tree expressed as percent defoliation to nearest 10% (USDA 1974).

References

Mason, R. R. 1970. Development of sampling methods for the Douglas-fir tussock moth. *Can. Entomol.* 102:836-45.

USDA. 1974. Final environmental statement, cooperative Douglas-fir tussock moth pest management plan. 562 pp. Unpubl.

Bark Beetles - *Dendroctonus frontalis* Zim., *Dendroctonus* spp.

Experimental Design:--This group of forest insect pests includes the southern pine beetle, mountain pine beetle, Douglas-fir bark beetle, etc. Test trees are generally mature, of even diameter at breast height and of the same overall height. Cut bolt sections, 15 to 18 inches long, may also be selected for test purposes (Frye and Wygant 1971). Treatments should be randomly assigned to trees or bolt sections.

Application Methods:--Insecticide formulations are applied in sufficient amounts for runoff to occur (spray to drip) using hand-held garden watering cans, compressed-air sprayers, or hydraulic spray equipment (Massey and Wygant 1954, Stevens 1959, Lyon 1965).

Sampling Methods:--Pre- and post-treatment counts are made for the numbers of bark beetle larvae, pupae, and adults per square foot in both standing infested forests and cut bolt sections (Lyon 1965, Ragenovich and Coster 1974, Buffam et al. 1973, Massey and Wygant 1954).

References

Buffam, P. E., C. K. Lister, R. E. Stevens, and R. H. Frye. 1973. Fall cacodylic acid treatments to produce lethal traps for spruce beetles. *Environ. Entomol.* 2:259-262.

Lyon, R. L. 1965. Structure and toxicity of insecticide deposits for control of bark beetles. USDA Technical Bulletin No. 1343. 59 p.

Lyon, R. L., and B. E. Wickman. 1960. Mortality of the western pine beetle and California five-spined Ips in a field trial of lindane. U.S. Forest Service Research Note PSW-166. 7 p.

Massey, C. L., and N. D. Wygant. 1954. Biology and control of the engelmann spruce beetle in Colorado. USDA Circular No. 944. 35 p.

Ragenovich, I. R., and J. E. Coster. 1974. Evaluation of same carbamate and phosphate insecticides against southern pine beetles and Ips bark beetles. *J. Econ. Entomol.* 67:763-5.

Schmid, J. M. 1972. Reduced ethylene dibromide concentrations or field oil alone kills spruce beetles. *J. Econ. Entomol.* 65:1520-1.

Stevens, R. E. 1959. Ethylene dibromide sprays for controlling bark beetles in California. U.S. Forest Service, California Forest and Experiment Station Note No. 147. 6 p.

Yasinski, F. M. 1956. Pilot test of ethylene dibromide in an oil solution for control of roundheaded pine beetle, Coconino National Forest. Forest Service Research Note RM-29. 2 p.

Exhibit 1

USE OF AEROSOL PROPELLANT TO APPLY INSECTICIDES

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This method is for the use of small universal aerosol devices to apply insecticides to run-off to small groups of plants.

The units, Universal Aerosol Kits®, manufactured by ICN Pharmaceuticals, Inc., Cleveland, Ohio, are very useful in applying insecticides to small groups of plants. Insecticide solutions or suspensions are mixed in 100-150 ml lots and placed in container attached to the pressurized can by means of a plastic holder. Applications with these devices simulates spraying to run-off with a larger sprayer.

Exhibit 2

GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Control of green peach aphids on greenhouse chrysanthemums with insecticides applied as foliar sprays.

Treatment	Application Rate	Mean no. aphids on indicated day after treatment[a]					
		1	2	6	14	21	27
A	0.25 gm	0	0	0	0	0	0.2
A	1.0 gm	0	0	0	1.0	1.2	0
B	0.25 gm	0.5	0	0	0	0	0
B	1.0 gm	0.2	0.5	0	0	0	0
Check	-	18.2	18	20	20	24	26

[a]/Means of 4 replications; 2 plants/replicate; aphids recorded from upper surface of 4 apical leaves/replicate.

Cultivar: 'Bright Golden Anne'

Stage of Growth: Vegetative, 4 wk after potting.

Application Equipment: 7.8 liter compressed air sprayer.

Temperature: Generally 23-24°C day, 16-16°C night.

Phytotoxicity: None noted in this test.

Remarks: Both materials were effective in controlling green peach aphids at rates used.

Exhibit 3

TESTS ON CARNATIONS FOR THE CONTROL OF THE TWO SPOTTED SPIDER MITE, *Tetranychus urticae* (Koch)

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An established bed of carnations was divided into .8 m^2 (9 ft^2) and an experiment laid out with 4 replications on April 12, 1974 at the Indiana State Soldier's Home greenhouse. At the time of application it was bright and sunny, the temperature was 35°C (96°F) and the relative humidity was 64%. Sprays were applied with a 3.8 liter B & G compressed air sprayer. Granules were app;ied by passing a Vibro-Seeder between the rows of carnation plants, plants were watered immediately. Aerosols were applied for 45 seconds per plot at approximately 46 cm (18 in.) from the plants.

A 30 cm (12 in.) sample of carnation stem and leaves was removed, placed in a paper bag and transported to the laboratory where the samples were brushed from the plants with a Henderson-McBurnie mite brushing machine. Mites removed from the plant were collected on 12 cm round glass plates. The mites were counted beneath a binocular, dissecting microscope.

There was some aerosol burn from A, and C caused some blanching of buds.

Samples were taken at time of treatment (T) and at T + 1, T + 7, (time of 2T 4/22/74) 2T + 7, 2T + 14.

The results of this experiment are shown in the following table:

Formulation Treatment	Average no. mites sample dates				
	T	T + 1	T + 7	2T + 7	2T + 14
A	-	.8	1.8	4	7.5
B	-	1.0	2.8	9.3	38.0
A	-	1.8	6.3	4.5	13.0
A	-	2.0	4.0	3	7.7
A	-	2.5	3.0	9.3	6.7
C	-	1.0	1.5	8	4.8
D	-	1.8	1.0	0	.3
E	-	.3	.5	13	21
F	-	8	7.5	27.8	25
Check - Untreated	4.3	8	10.5	11	17.5
LRSD 5%	-	5.4	5.4	9.7	13.5
LRSD 1%	-	-	-	13.1	18.2

Examination of these data indicate that all of the treatments except F reduced the population of the two spotted spider mite significantly in the first experiment. The second treatment did not result in a dramatic reduction of the numbers of mites. D was the outstanding material for control of the two-spotted mite on carnations. Of the series of A treatments applied, the granular formulation seemed to perform the best and gave the longest period of effectiveness.

Exhibit 4

CHRYSANTHEMUM TESTS
GREEN PEACH APHID CONTROL

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CROP: Greenhouse chrysanthemums (pot): Cvs. "Orange Bowl", "Mermaid", "Neptune", "Vermilion", "Ice Follies".

STAGE: Nearly full bloom

PEST: Green peach aphid, *Myzus persicae*

METHODS: Chemicals were applied as soil drenches onto 21.2 cm diam. pots, each pot containing 5 plants of one variety. Each treatment was applied onto 1 pot of each variety.

TREATMENT DATE: April 21, 1972

TEMPERATURE: 21-23°C

Treatments Applied April 21, 1972	Pretreatment Count		May 7, 1972	
	No. of blooms with live aphids	with no live aphids	No. of blooms with live aphids	with no live aphids
Check	49	0	49	0
A	73	0	10	63
B	69	0	34	35

Phytotoxicity

None, blooms are open on all varieties

Exhibit 5

GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Materials and Methods

The experimental design to test the efficacy of four systemic insecticides to control aphids on chrysanthemums included a control and insecticide treatments of A, B, C and D at dosages of approximately 1/2X, 1X and 3X recommended rates applied to the following ten chrysanthemum varieties:

1 - Mefo
2 - Southern Comfort
3 - Fred Shoesmith
4 - Albatross
5 - Southern Sun
6 - Indianapolis
7 - Princess Anne
8 - Iceberg
9 - May Shoesmith
10 - Detroit News

The design was replicated four times.

Five cm rooted cuttings of these varieties were obtained from Yoder Brothers of Barberton, Ohio. The rooted cuttings were planted in 12.7 cm pots containing the Cornell Peat-lite mix. The plants were maintained on a constant feed program of a 20-20-20 fertilizer and grown at 21°C day - 15°C night temperatures. They were brought to flower under standard commercial practices. One week after potting ten green peach aphids were placed on each plant from cultures maintained at the insectary. Three weeks after potting insecticides were applied to the soil at the following rates:

Formulation	Dosage of formulated material (recommended rate)		
	1/2X	1X	3X
15% granular	.5 gm	1 gm	3 gm
19% granular	.5 gm	1 gm	3 gm
10% granular	.5 gm	1 gm	3 gm
R LC	.5 gm	1 gm	3 gm

The same applications were repeated 8 weeks after planting, so that the insecticide treatment consisted of two applications during the production of the crop.

Twelve weeks after potting, when flowers were in full bloom, the number of aphids on the top leaf of each plant was counted. The height of the plant was measured and the level of phytotoxicity was evaluated on a scale of 0-5 (0 = none, 5 = total). Analysis of variance of these data were computed using the analysis of variance, program for factorial design developed by the Computer Activities Group at Cornell.

Results and Discussion

Three dependent variables: (1) the number of aphids per top-leaf, (2) the relative level of visible phytotoxicity, and (3) plant height, were observed as measures of insecticide efficacy in this experiment. A three-level factorial design including insecticide treatment, dosage and plant variety was used for the analysis of variance for each of the dependent variables.

Aphid Control:--Although there were significant differences in the number of aphids per top-leaf at all three levels, the differences between insecticide treatment means ($F = 74$) were much greater than those between dosages ($F = 4$) and varieties ($F = 5$). When all dosages were considered, the number of aphids per top-leaf was lowest in the 10G treatment in all varieties ($\bar{x}$ 8).

GRANULAR SYSTEMIC INSECTICIDES FOR GREEN PEACH APHID CONTROL ON CHRYSANTHEMUMS

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Regular and latered release formulations for green peach aphid control on pot- grown chrysanthemums.

Treatment[a]	Rate (gm/pot)	Mean no. aphids/plant at indicated interval pre- and posttreatment[b]						
		Pretreat	24 hr	72 hr	7 day	14 day	21 day	28 day
Regular	0.1	62.8	29.5	0	0	0	0	2.5
Regular	0.05	65.5	55	3.5	0	.2	0	10.5
Altered release	0.1	105.2	125	22.2	0	0	0	19.2
Altered release	0.05	68	325	4.0	0	0	0	14.8
Untreated	-	86.5	127.2	153.2	281.2	340.2	490.2	1020.5

[a] Applied 10/22/74; all treatments applied to soil surface; cv. "Bright Golden Anne"; plants approximately 6 wk old.

[b] Means of 4 replicates; aphids recorded from 1 plant/rep.

Temperatures were variable, depending on sky cover. Generally, the range was 21-22°C day, 18-19°C night.

No phytotoxicity noted.

Was very little difference in effectiveness of the 2 formulations in controlling green peach aphids in this test.

Exhibit 6

Exhibit 7

FLOWER THRIPS EXTRACTION

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Extracting thrips or aphids out of the flower or plant samples is accomplished with Berlese funnels. With this technique, the samples are collected in alcohol and labelled so that if time does not permit an immediate count, the count can be made later.

Exhibit 8

FLOWER THRIP EXPERIMENT

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An established bed of carnations was divided into 1 m^2 plots and an experiment laid out with 4 replications on April 12, 1974 at the Indiana State Soldier's Home greenhouse. At the time of application it was bright and sunny, the temperature was 35°C (96°F) and the relative humidity was 64%. Sprays were applied with a 3.8 liter B and G sprayer and, granulaes were applied with a Vibra-seeder passed between the rows of carnation plants and watered immediately. Aerosols were applied for 45 seconds approximately .5 m from the plants.

Carnation flowers from each plot were removed, placed in paper sacks and transported to the laboratory where the flowers were split open and placed in Berlese tunnels for 24 hours. The thrips driven from the blossoms were caught in vials containing 70% alcohol and then counted in a watch glass under a binocular, dissecting microscope. Samples were taken at the time of treatment (T) and at T + 1, T + 4, T + 7, T + 10 (time of second treatment 4/22/74) and samples were taken at 2T + 7 and 2T + 10.

There was some aerosol burn from A and C caused some blanching of buds.

The results of the experiment are shown in the following table:

1974

FLOWER TRIPS, *Frankliniella tritici* FITCH ON CARNATIONS

INDIANA STATE SOLDIER'S HOME

Formulation Treatment	Average No. thrips/flower Sample Dates							
	T	T + 1	T + 4	T + 7	T + 10	2T + 4	2T + 7	2T + 10
A	-	33.6	2.3	1.5	4	2.8	5.3	4.8
B	-	8.5	3.0	23.3	3.3	11	17.8	12
C	-	27.5	0	2	11	8.3	6	12.8
D	-	31	7.5	1.8	3.8	5	5.3	10.8
E	-	31	4.3	2	2.3	19.3	5.8	20.3
F	-	22	8.5	2.5	2.5	7	11	12.5
G	-	15.3	11	9	6	32.3	10.8	9.8
H	-	37	8	7.3	24.5	53.8	1	21.5
Check	61.3	36	15	14.5	19.5	38.3	16	28.3
LRSD		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Exhibit 9

THE EFFECTIVENESS OF VARIOUS INSECTICIDES FOR THE CONTROL OF THE GREENHOUSE WHITEFLY ON GERBERA - San Jose, 1972

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The tabular data illustrate the use of pre-treatment counts in establishing the presence of a infestation, suitable sampling methods and sampling intervals.

Material	Lbs. act. per 100 gals.[1]	Pre-Treatment count	Post treatment count after:[2] 12 days	20 days	27 days
A	0.5	9,080	93 a	992 a	64
B	0.5	11,152	1,719 b	957 a	2,212
C	0.5	7,228	6,007 c	4,488 ab	3,254
D	1.0	12,896	9,232 c	1,730 a	683
E	0.5	11,604	21,527 c	-	-
F	0.5	10,748	10,956 c	-	-
G	0.5	10,424	11,439 c	-	-
H	0.5	12,732	12,102 c	-	-
I	0.5	11,954	20,004 c	-	-
Check	-	11,430	11,532 c	7,443 b	6,037

[1] Full coverage sprays applied on March 31.

[2] The number of whiteflies found on 5 leaf punches 4 cm in diameter. Counts followed by the same letter are not significantly different at the 5% level.

No injury was evident from any of the treatments.

Exhibit 10

WHITEFLY CONTROL ON POINSETTIAS

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Poinsettias were grown in 10.2 cm diam. pots.

Granules were broadcast on foliage of closely-spaced plants with a shaker jar; granules were applied to foliage from pre-weighed dosages in glass vials.

Temperatures during the experiment varied but were generally 21-22°C day and 18-20°C night.

No phytotoxicity was observed throughout the trial.

Treatment[a]	Cultivar[b]	Mean no. nymphs on indicated day posttreatment[c]				
		14	21	37	83	104
Soil (Broadcast)	White	75.8	10	0.2	0.2	26.5
	Red	216.0	7.2	0	1	17
Wet Foliage (Broadcast)	White	166.5	14.5	4.8	0.5	34.5
	Red	159.8	8	4.2	4.8	24.0
Dry Foliage (Broadcast)	White	329.0	26.2	0.5	0	3.0
	Red	143.0	24.2	0.8	2.2	18.2
Untreated	White	460.2	45.5	76.8	70.5	52.5
	Red	206.5	39.8	30.2	50.2	18.5

[a] Applied 10/30/73; foliar treatments applied at rate of 4 oz. formulation/100 ft^2; soil treatment applied at rate of 0.1 gm formulation/10.2 cm diam. (= 4-in.).

[b] White = "Ekkespoint C-1 White"; Red = "Dark Red Hegg".

[c] Means of 8 replications; whitefly nymphs recorded from 2 subapical leaves/rep.

EVALUATING INSECTICIDES FOR GREENHOUSE WHITEFLY CONTROL ON POINSETTIA

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Similarly infested 15.2 cm tall (6-in.) plants were selected, and each treatment applied to 4 plants (1 plant = 1 replicate). Leaves for future sampling of immature stages were marked with white tags. Temperature at application was 28°C (80°F). Application was made with B & G sprayers operating at 30 psi. Counts of the number of live nymphs and empty "puparia" were made 7 and 14 days post treatment. No mention was made of the number of leaves or leaf sections sampled. This should be made clear in the future use of this or similar method.

Results of Whitefly Experiment

Material	Gals. Water	Counting Dates T Live	T Emerged	T + 7 Live	T + 7 Emerged	T + 14 Live	T + 14 Emerged
A	3/4 lb	—	—	71.5a	25 a	157.3a	4.8
B	Aerosol	—	—	124 a	10 a	151.3a	3.3
C	1 qt.	—	—	145.2a	31 a	178.5a	20.5
D	Aerosol	—	—	158.8a	70.3b	190.9a	64.8
E	75%	—	—	193.5a	7.3a	217.5a	5.0
F	2 qts.	—	—	226.5b	20.5a	203.5a	10.8
G	Aerosol	—	—	470.8b	84.3b	345.3b	41.0
Check	Untreated	162.3	71.2	220 a	75.8b	196.7a	45.0
L.R.S.D. 5%		—	—	132.5	47.7	110	NS
L.R.S.D. 1%		—	—	216.6	—	180	NS

Exhibit 12

EVALUATION OF INSECTICIDES FOR CONTROL OF THE CYPRESS TIP MOTH, *Argyresthia cupressella*, ON *Thuja* (ARBORVITAE), Berkeley, Calif. 1973-74

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Treatment[1/]	Act. toxicant, lb./100 gal.	Avg. no. cocoons/ 10 grams foliage[2/]	Unsightliness rating[3/]
A (3 EC)	0.5	0.32	1.5
A (3 EC)	1.0	0.30	1.3
B (75 EC)	1.0	0.43	1.3
C (4,320 IU/Mg)	2.0	10.53	3.8
D (2 EC)	0.5	0.37	1.5
E (4 EC)	0.5	1.57	2.0
Untreated	-	14.95	3.8

1/ Treatments applied May 16, 1973, when adult moths were active. Full coverage sprays applied by hand compression sprayer to single plant (4-6' tall) plots replicated 4 times. No evidence of phytotoxicity noted from any treatment.

2/ Cocoon counts made Mar. 15, 1974 after taking 4, 4" terminal samples of foliage from each plot. Foliage samples weighed to standardize foliage volume.

3/ 1 = no unsightliness attributable to tip moth, to 4, representing severe browning of plants. Rating of 2.0 or over considered unacceptable.

Exhibit 13

EVALUATION OF GRANULATED INSECTICIDES FOR CONTROL OF WHITEFLIES ON CONTAINER-GROWN *Celtis australis*, Saratoga, Calif. 1973

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Material[1]	Act. tox., lb./acre	Formulation (g.) used/ 6" pot	Immature whiteflies/20 leaves after (days):[2] 20	34	39	48	55	62	74
A 10 C	5	.1	17	16	10	14	12	13	36
A 10 C	7.5	.15	21	6	7	7	7	20	11
A 10 C	10	.2	13	2	0	7	11	11	35
B 1 C[3]	10	2	24	19	18	39	24	95	396
Untreated	-	-	41	116	50	65	106	73	72

[1] Applied to single 1 gal. pots by sprinkling granules on soil surface. Plants 12" tall, replicated 4 times. No phytotoxicity noted.

[2] 5 leaves taken from each plant at intervals noted, and examined under magnification. Nymphs and pupae counted.

[3] On 8-8-8 fertilizer.

Exhibit 14

EVALUATION OF INSECTICIDES APPLIED AS SPRAYS FOR CONTROL OF THE BARBERRY LOOPER, *Coryphista meadi*, ON CONTAINER GROWN OREGON GRAPE, *Mahonia aquifolia*, Saratoga, Calif. 1973

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Material[1]	lb./100 gal.	No. living larvae/6 plants after (days):[2] 5	12	26
A	1.0	0	0	1
B	.5	0	0	2
C	1.0	0	0	1
D	.5	0	1	0
E	[3]	1	13	4
F	[4]	12	21	8
G	.5	0	1	2
H	.5	0	10	6
Untreated	-	130	71	14

[1] Applied to single plant (12-24" high) plots, replicated 6 times, on June 7. Full coverage sprays applied using hand compression sprayers. No phytotoxicity noted from any treatment.

[2] All living larvae on each plant counted at intervals noted.

[3] 2 lb. wettable powder formulation, containing 4,320 I.U./Ng used/100 gal. water.

[4] 0.5 lb. wettable powder formulation, containing 6,000 A.U.Ak./Mg, used/ 100 gal. water.

Exhibit 15

EVALUATION OF 3 TYPES OF APPLICATION OF INSECTICIDES FOR CONTROL OF THE LETTUCE ROOT APHID, *Pemphigus bursarius*, ON LOMBARDY POPLAR[1/], Lompoc, Calif, 1974

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Material	Actual toxicant in lbs. per acre	No. galls counted in 2 min. period	No. galls opened for aphid count	No. live aphids in galls opened	% galls with live aphids
	Spray Applications[2/]				
A (50 WP)	0.5	67	60	1048	24
B (75 SP)[3/]	1.0	28	27	0	0
C (2 EC)	0.375	41	40	47	3
Untreated	-	128	78	4953	99
	Paint-on Applications[4/]				
C (2 EC)		38	36	501	27
B (2.67 EC)		31	29	538	34
Untreated		63	54	2588	89
	Trunk Implementations[5/]				
D (86 Technical)		109	28	876	55
D (86 Technical)		129	40	787	33
Untreated		188	40	2097	98

1/ Treatments applied Apr. 5, 1974. Evaluations made May 16, 1974.

2/ Sprayed to point of complete coverage using hydraulic equipment at 200 psi. Four replications of all treatments; single tree plots.

3/ Slight marginal or interveinal necrosis (phytotoxicity) resulted from treatment.

4/ One foot wide encircling band applied at ground level, using paint brush and undiluted insecticide formulation. Three replications of all treatments, single tree plots.

5/ One and 2 ml. Mauget units used, respectively. Applied 6' below point of first tree branching. Six inch interval. Two replications of all treatments; single tree plots.

Exhibit 16

EVALUATION[1/] OF INSECTICIDES AND SPRAYING SCHEDULES FOR CONTROL OF KUNO SCALE, *Lecanium kunoensis*, ON PYRACANTHA, Walnut Creek, Calif. 1973-74

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Material	Act. tox., lbs. per 100 gal.	Date(s) of application[2/] in 1973	Avg. no. scales/inch of twig growth[3/]	% scale reduction[3/]
A (75 SP)	1.0	June 16	2.23	32
A (75 SP)	1.0	June 16, July 5	0.65	80
B (3 EC)	0.5	June 16	0.97	70
B (3 EC)	1.0	June 16	0.82	75
C (80 Spr.)	1.0	June 16	1.33	59
C (80 Spr.)	1.0	June 16, July 5	0.45	86
Untreated	-	-	3.28	-

1/ Single plant plots sprayed to point of complete coverage using hand compression sprayer. Four replications.

2/ Peak of crawler emergence in 1973 occurred approximately June 1.

3/ Evaluation made May 27, 1974; surviving females counted on 5 twig samples, each approximately 11 inches long, collected from each plot.